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XIV. *Some observations relating to the function of digestion.* By A. P. W. PHILIP,
M.D. F.R.S. L. & E.

Read January 16, 1829.

NO arguments are necessary to convince us of the importance of that function on which all parts of our frame depend for their nourishment. In one respect its organs may be regarded as of greater importance than even those which are more immediately essential to life. The sympathies of the stomach and first intestine are both more powerful and more extensive than those of any other part, and consequently more generally and in a greater number of ways contribute to the cause, and influence the course of all our more serious diseases.

I am induced to trouble the Society with the following observations, in the hope that I shall be able to place before them some points relating to the function of the stomach in a clearer point of view than has hitherto been done. In former papers which the Society have done me the honour to publish, and more fully in a Treatise on the Vital Functions, I have endeavoured by experiment to trace the different steps of the process of digestion in the stomach. It appeared that the food remains in a quiescent state, except that the part of it which lies next the stomach, as soon as it has undergone the effect of the gastric juice, is, in consequence of food thus prepared exciting a peculiar action in the muscular fibres of this organ, carried on towards the pylorus; through which it is propelled into the intestine, the next portion of food thus brought into contact with the stomach undergoing the same process; and so on, till the whole is in a state proper for that part of the digestive process which belongs to the first intestine.

Thus the muscular fibres of the stomach are in continual action during its function; for the gastric juice pervading the contents of the stomach to a certain extent, the change effected by it on each particular portion of the food is

nearly completed before the food is actually in contact with the stomach, as may be seen by inspecting that of an animal killed a few hours after a meal ; and consequently is not detained when in contact with it. There is therefore a continual motion of the food in contact with its surface towards the pylorus, and the less digested part is continually approaching its surface.

It follows then that a failure of the function of the stomach may arise either from a proper gastric juice not being supplied, or the muscular power of the stomach failing to carry onward the digested part, and thus regularly to present to the stomach a new surface of food to be acted upon by that juice. It further appeared, that for the first of these purposes the power of the nervous system is necessary, the secretion of gastric juice failing as soon as the stomach is deprived of any considerable part of this power ; but that the nervous power is not necessary for the other, the muscular power of the stomach still carrying on towards the pylorus any digested food which happens to be in it, or any food which had been acted upon by gastric juice which happened to be in it at the time, however much its nervous power be impaired ; and this office is, as far as we can see, as readily performed as when the nervous power of the organ is entire.

The muscular fibres of the stomach therefore are stimulated by its contents, in the same way as those of the heart by the blood, the usual action of both being wholly independent of the nervous system, an inference confirmed by many other experiments beside those here referred to.

I have, as appears from the papers which the Society have done me the honour to publish, attempted to go a step further, and to show experimentally that the office of the nervous power in preparing the gastric juice, may be correctly imitated by exposing the living stomach to the influence of a voltaic pile after the supply of nervous power is interrupted. Those who were at first inclined to doubt this fact, have since publicly acknowledged, on witnessing the experiments, that the digestive process of the stomach supported by galvanism, is, as far as we can see, as perfect as that supported by the nervous power itself.

It is therefore evident that in the formation of the gastric juice, a chemical power can be substituted for that of the nervous system. I do not mean that, strictly speaking, its formation is to be regarded as a mere chemical process,

because it is only in a living stomach that galvanism can have such an effect ; but this effect bears too strong an analogy to other chemical results to be wholly separated from them, although what we call life, whatever that may be, is necessary to its production.

The same effect, and one certainly of a very complicated nature, is here produced by the nervous power and a chemical agent ; because when the latter is substituted for the former, the same effect takes place. It is a simple matter of fact. But it is maintained by some gentlemen that the same effect may be produced by a mechanical agent*. They have related several experiments which appeared to them to prove, that when after a part of the eighth pair of nerves is removed, and thus the due secretion of gastric juice prevented, it may be restored by mechanically irritating the cut ends of the lower portions of the divided nerves. If such be the fact, it must materially influence our views both with respect to the function of digestion and the other secreting processes of the animal body.

In judging of the result of such experiments, several things must be taken into the account which appear to have escaped the attention of those gentlemen.

At the time the animal is fed, in preparation for the experiment, there may be some food in the stomach, from previous meals, more or less digested, and there is always some gastric juice ready to act on any new food which may be presented to it. It is evident therefore, that although the secretion of gastric juice ceases at the moment of the excision of part of the eighth pair of nerves, some digested food must be found in the stomach for some hours after the operation ; for, as I have ascertained by numerous trials, many hours are required in such experiments for the stomach to propel into the intestine the remains of food previously digested, or that digested by the gastric juice previously formed.

When therefore the contents of the stomach are examined in five or six hours, and generally even in ten or twelve, after the operation, more or less digested food is found lying next the surface of the stomach. But when the

* See a paper entitled, *Mémoire sur le mode d'action des nerfs pneumogastriques dans la production des phénomènes de la digestion.* Par MM. BRESCHET et MILNE EDWARDS (lu à la Société Philomatique, le 19 Février 1825).—(Extract des Archives generales de Médecine.)

animal survives the operation eighteen, twenty, or more hours, undigested food alone is found in it. The cause of so long a time being required wholly to expel the food, which has undergone any degree of the digestive process, appears to be, that as digested food alone excites that action of the stomach which propels it into the intestine, and the more perfectly it is digested, it excites this action the more readily, the last part of the digested food which has but imperfectly undergone the digestive process is expelled very slowly, so that it is very long before food wholly undigested alone is left.

That the longer the animal lives after the excision of part of the eighth pair of nerves, the less digested food is left in the stomach, is a fact now admitted by all who assisted at the experiments. Among the great number who have witnessed and been satisfied with their result, are Sir HUMPHRY DAVY, Mr. THOMAS ANDREW KNIGHT, and Mr. BRODIE, gentlemen whose experimental accuracy, in the opinion of the public, has never been surpassed.

Of this fact, the gentlemen to whose paper I have referred, are not aware. They maintain, indeed, that the only effect on the digestive process produced by the excision of part of the eighth pair of nerves, is, that it becomes more tedious, being as perfect as when the nerves are entire, if a sufficient length of time be afforded. In speaking of the animals in which part of the eighth pair of nerves has been cut out, and comparing them with the healthy animal, they say : “ *Enfin, si on laisse écouler un espace de temps plus grand encore entre l'opération et la mort des animaux, on pourra trouver que la digestion est complètement achevée dans l'un comme dans l'autre cas.*”

It will easily be perceived to what errors, respecting the effect on digestion, of depriving the stomach of the office of the eighth pair of nerves, this misconception must lead. Its effect was increased in the experiments referred to, by the different animals in each experiment having been confined to the same quantity of food. The most hungry would of course digest it fastest and most perfectly. To judge fairly of the result of the experiment the different animals must be allowed equally to satisfy their appetite, to eat till, from their manner of eating, it is found that the appetite has equally abated in all.

Such are the circumstances which I conceive misled those gentlemen who maintain that they can produce a sensible effect on the contents of the stomach by any mechanical irritation of its nerves.

They also err in supposing that the muscular fibres of the stomach can be excited by irritating the eighth pair of nerves in the way that a muscle of voluntary motion may be excited through its nerves. The digested food is the natural stimulus of the muscular fibres of the stomach in its usual function, as the nervous power is of the muscles of voluntary motion in theirs ; and we cannot through the nerves excite the former as we do the latter class of muscles. The muscular action of the stomach resembles that of other hollow muscles, in being excited by its contents.

The mechanical irritation employed by those gentlemen, in endeavouring to excite the digestive process after a portion of the eighth pair of nerves had been removed, was that of a thread attached to the cut extremities of the lower portions of the eighth pair of nerves and fastened to the neighbouring muscles, by which the motions of respiration kept the part in a state of constant irritation.

In my Treatise on the Vital Functions, a similar experiment is related, in which the cut extremity of the lower portions of the nerves was fastened to a thread tied round the neck of the animal, by which it was in like manner kept in a state of constant mechanical irritation; yet in the stomachs of the animals after they had lived more than twenty hours,—for the experiment was made more than once,—nothing but undigested food was found. This experiment, with some others connected with it, was made publicly in the rooms of the Royal Institution ; and all who felt an interest in the subject admitted to see the results, nor was there one who expressed a doubt respecting them.

As, however, in the experiments just mentioned the position of the nerves was more disturbed, and the thread was not applied as in the experiments to which I have referred, Mr. CUTLER, at my request, was so good as to make the following experiment.—Three rabbits, after a fast of the same duration, were fed in the same way. In two of them a portion of each of the eighth pair of nerves was removed. The third rabbit was left undisturbed. In one of those in which the portions of nerve were removed, the cut end of the lower part of the nerves was by means of a bit of thread fastened to the neighbouring muscles, as in the experiment referred to. This rabbit died in ten hours, at which time the others were killed in the usual way.

Mr. CUTLER then took out the stomachs of all of them, slit them open, and laid them on the same plate ; and Mr. BRODIE was requested to examine and

give his opinion respecting their contents, without having been told which was which. He at once pointed out the healthy stomach, the whole contents of which had undergone the action of the gastric juice. After carefully examining, and with an instrument moving about the contents of the other stomachs, he declared he could discover no difference in them. Both stomachs were chiefly filled with undigested food, the animals not having lived long enough after the operation for the expulsion of some imperfectly digested food that still remained in both.

The foregoing experiments convinced those who witnessed their results, that the irritation caused by the attachment of the cut end of the nerves to the muscles, had no effect whatever in promoting the digestion of the food.

Were it possible, as in the case of the nerve of a muscle of voluntary motion, to excite the eighth pair to perform its office after its communication with the brain is wholly intercepted, it is surely impossible that this could go on for many hours, which are necessary for the digestion of the food. A nerve of voluntary motion, if kept in a state of excitement after its separation from the brain or spinal marrow, loses its power in a very short time, at most a few minutes.

The result of the foregoing experiment may be known before the death of the animals. It appears from what was said in other papers which I had the honour to lay before the Society, and which were published in the *Philosophical Transactions*, that the effect of the excision of part of the eighth pair of nerves on the lungs, as well as on the stomach, is obviated by galvanism, the animals (the dog and rabbit were those on which the experiments were made) breathing under its influence as freely as in health. It is clear, that if the power of the nerve be restored, its restoration must be as evident in the function of the one organ as the other, these nerves being equally essential to both. In the foregoing experiments both the animals were affected with extreme dyspnœa, the mechanical irritation of the nerves having no more effect in relieving this symptom, than in promoting the due action of the stomach.